The difficulty of injecting the glomeruli *uniformly* even in fresh kidneys is comprehensible, as is also the lack of uniformity among the glomeruli in the action of circulating toxic substances.

A lead may be given concerning the causation of albuminuria under conditions not far removed from the physiological; it is a very old observation that complete arterial interruption of the circulation in the kidney for a short time is followed by albuminuria. If intermittence of glomerular flow is a normal phenomenon it would appear that albuminuria might occur if for any reason the duration of the normal intermittent cessation of flow increased.

I will give the briefest résumé of the chief points presented:

1. New evidence has been secured that increment of blood-pressure, uncomplicated by increment in velocity or volume of blood flow in the kidney, increases urine formation. This is regarded as added support of the filtration hypothesis.
2. Evidence has been secured indicating that some of the most weighty objections to the filtration hypothesis can be reasonably explained in a manner consistent with it.
3. Indications have been shown that nervous stimuli and chemical substances may exert different degrees of effective influence upon the afferent and efferent vessels of the glomerulus and that this may be a factor in that automatic regulatory control of glomerular filtration which is responsible in part for the maintenance of constancy of blood composition.
4. And, finally, a new description of the mode of circulation through the glomerular vessels has been presented which, when verified and extended, we hope will be of service in the study of the normal and pathological physiology of the kidney.

A FURTHER STUDY OF THE QUANTITATIVE VARIATIONS IN THE VIBRATION SENSATION.[1]

By Edward J. Wood, M.D.,
WILMINGTON, NORTH CAROLINA.

The first contribution to the study of the vibration sensation was made by Rumpf[2] in 1889. A steel tuning-fork was used, and the handle was so made that it was suitable for application of it to the skin surface after the vibration was started. Forks of different rate of vibration were used in this study, as it was found that in different parts of the body different rates of vibration were better appreciated. Rumpf regarded the procedure merely as a means for the more careful study of skin sensation.

---

[1] Read before the Association of American Physicians, May 11, 1921.

[2] Neurol. Centralbl., 1889, 8, 185.

In 1897 Treitel,[3] unaware of Rumpf's work, experimented with a tuning-fork of 128 vibrations, with which the variations in the length of time of the perception of the sensation were studied. He discovered the important fact that under certain pathological conditions tactile sensation and vibration sensation bear a different relation to each other and the one may be altered without alteration of the other. Contrary to the conclusion of Rumpf he decided that the vibration sensation is to be distinguished from a sense of pressure and a sense of touch.

Max Egger is usually regarded as the first to study the vibration sensation. Certainly, he was the first to demonstrate the feasibility of testing the sensibility of bones by means of a tuning-fork. The idea was suggested by the extreme sensitiveness of periosteal lesions. By lifting up a fold of skin in a thin subject and placing it between a vibrating tuning-fork and a fixed object only the very slightest vibration was detected. When the skin was allowed to fall back into place and the instrument was applied it was found that the appreciation was increased tenfold.

Egger[4] demonstrated that this perception of vibration sensation was entirely independent of the presence or absence of cutaneous sensibility. More recently Goldscheider showed that Egger was in error in his conclusion that the vibration sensation is perceived only through bone. He found that the soft parts are susceptible, though not to so marked a degree, owing to the physical property of the tissue. Goldscheider[5] further thought that the observation was dependent in part on the condition of cutaneous sensibility. He experimented with anesthetization of the skin. To test the cutaneous sensibility the instrument was very lightly applied to the skin surface, and to test vibration it was applied much more firmly through the compressed skin. He did not regard it as a specific sensation but as an expression of the sensation of rhythmic interrupted irritation of the nerves that are responsible for the sensation of contact or pressure.

Bing is quite emphatic in stating that through cocain anesthesia tactile, pain and temperature sense may be abolished while the vibration sensation is preserved, and, further, that it is usually not noticeably decreased. He shows many good grounds for the sharp separation of tactile and vibration sensation.

L. F. Barker[6] is disposed to regard the sensation of vibration as due to the result of the stimulation of the touch points in the skin.

---

[3] Arch. f. Psychiat., 1897, 29.

[4] Jour. de physiol. et de path. gén., 1899, No. 3, 1. Rev. neurol., Paris, 1908, 16, 345-351. Comptes rendus de la soc. de biol., 27 Mai, 1899, p. 423. Comptes rendus de la soc. de neurol., 4 Febr., 1904.

[5] Berl. klin. Wchnschr., 1904, No. 14.

[6] Monographic Medicine, vol. 4, p. 130.

He says that though this sensation may disappear before there is complete tactile anesthesia, still it seems to indicate that among the earlier disturbances of tactile sensation must be counted an inability to perceive successive impulses of short duration as separate sensations.

In 1903 Rydel and Seiffer[7] gave to the vibration sensation the name pallesthesia, which was a step in the direction of separating it as a different sensation from tactile and other sensations.

For clinical purposes Bing preferred to use the Gradenigo vibrator. A clear description of this instrument is not available. It seems to depend on an optical device as the means of determining a point of fixed amplitude. Barker preferred the C fork of 128 vibrations provided with a Gradenigo triangle on one prong, which permits, he says, of the application of vibrations of very different numbers and the number at the instant of vibration disappearance may be exactly recorded. During the progress of this work various instruments with the Gradenigo triangle were used, but the results did not seem to justify a continuance because of the difficulty in general standardization. It seems justifiable to recall to the reader that a tuning-fork can only vibrate at a fixed rate regardless of the violence of the starting blow. The only thing the blow can alter according to its degree is the amplitude of the vibration or the "degree of swing." To reach some means whereby the amplitude can be standardized is ever the difficulty in perfecting an instrument for quantitative work.

R. T. Williamson,[8] the English pioneer in the study of the vibration sensation in neurology, mentions in his writings the advantages of the Gradenigo instrument. He was impressed with the fact that by it sensation in different parts of the body can be accurately measured. Williamson worked with a C^1 fork nine inches long with prongs five and a half inches long.

In 1911 J. L. M. Symns,[9] working in Guy's Hospital, adopted a tuning-fork for quantitative work which made possible the exact charting in numerical ratio of the responses of the subject in different points on the body surface. The instrument of Symns has a small "window" placed between the prongs at the free ends. If the amplitude is wide enough the prongs separate sufficiently to allow to be seen the two little slots which differ slightly in depth. As soon as the vibration dies out sufficiently the window or slot is covered up. Unless the vibration is quite active the window will not appear. The observer strikes the instrument and then holds it up between his eye and a bright light, preferably a window, and continues to watch the gradually lessening light which is allowed to pass through the slot. At the instant when no more light can be detected the handle of the instrument is applied to the bony point under consideration and the subject told to note the vibration carefully, and at the instant when the vibration is no longer detected to give a suitable signal. The time during which the sensation is felt is recorded in seconds. Symns used a stop-watch, but it is not essential and has the disadvantage of requiring an assistant.

---

[7] Arch. f. Psychiat., Berlin, 1903, 37, 488–536. Neurol. Centralbl., 1903, No. 7. Berl. Ges. f. Psych. u. Nervenkr., 9 Marz, 1903.

[8] British Med. Jour., July 20, 1907.

[9] British Med. Jour., 1912, 1, 539. Guy's Hospital Reports, 1912, 66, 120. Quarterly Jour. Med., 1917, 2, 33–58.

The present work[10] was planned to serve as a continuance of the observations begun by Symns in the same clinic in 1911. Dr. Hurst and Dr. Symns were of the opinion that the normal range established by the latter had been based on too small a number of cases. One hundred normal individuals were studied by me in making a graph of the normal variations. The subjects were bed patients suffering from no nervous disease, willing to coöperate in the test and mentally intelligent. The graph constructed on this series of normal observations varied markedly from that constructed by Symns on a fewer number of observations. This was found to be due to the difference in the two instruments used. Through the help of Mr. H. G. Drew, of Messrs. Down Brothers, Ltd., of London, the makers of the instrument, it was soon learned that while the instrument used in the present work and that used by Symns were both of 108.5 double vibrations per second, and with identical windows the sources of difference could be readily accounted for and in large measure eliminated in future manufacture. Variations in weight and temper of the shaft caused a variation in vibration appreciation. A vibration of 2 mm. swing at the fork end is differently transmitted at the handle end if the rigidity of the fork varies. The instrument used in this work has been carefully weighed and measured by the manufacturer and made the standard. The window, which is really a double slot, has been carefully registered and every precaution will be taken to manufacture instruments conforming to it. It must be remembered, however, that a hand-wrought instrument can never be exactly duplicated, and it is not possible to exactly reproduce temper. It was thought desirable to standardize the instruments in such a way that a normal graph might be supplied with each instrument to facilitate the exact recording of the curve in each individual case.

In the diagrams it will be noted that the observations are made on various bony points of the body and recorded in seconds. The investigation is done in many other ways by a large number of observers. Dr. Henry Head does not use a windowed instrument and does not select the bony points used in the present work. One important part of his examination is timing the period during which the vibration can be detected on one side after the vibration can no longer be detected on the other side. That is, he holds the vibrator in contact with a part on the right side until the vibration cannot be felt, then quickly transfers the instrument to the other symmetrical part on the left side and notes the time in which the lessening vibration can be felt. The procedure is then reversed. Dr. Gordon Holmes uses a simple heavy tuning-fork without window and does not make time observations with standardized amplitude. His conclusions are based more on qualitative returns than on quantitative.

---

[10] Guy's Hospital Reports, January, 1921.

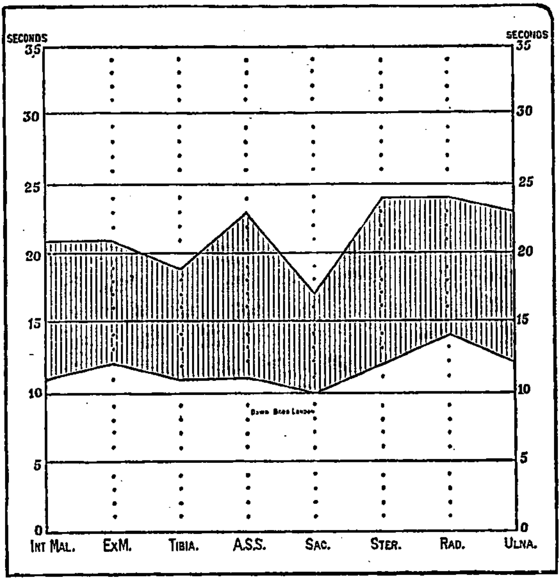

FIG. 1.—Normal range established in 100 non-neurological cases.

It was thought by those interested that the standardization of an instrument with a standard normal range, as has been attempted in this work, might open the way for numerous observations by many observers, resulting in the accumulation of data which is much needed before final acceptance of many of the claims to be made can be expected.

The justification for this present work is the fact that until quantitative variations are appreciated the value of the test is lost at a time when its aid is most needed. Before total loss of vibration appreciation occurs there is a gradual dimming which with this instrument can be exactly recorded day by day and the progress of the process noted. For example, in tabes dorsalis there occurs late in the disease frequently an entire loss of vibration appreciation in the lower half of the body; but, on the other hand, early in tabes before other signs of recognized value appear it will be found that there is a definite quantitative diminution of the time during which these vibrations of standard amplitude are felt.

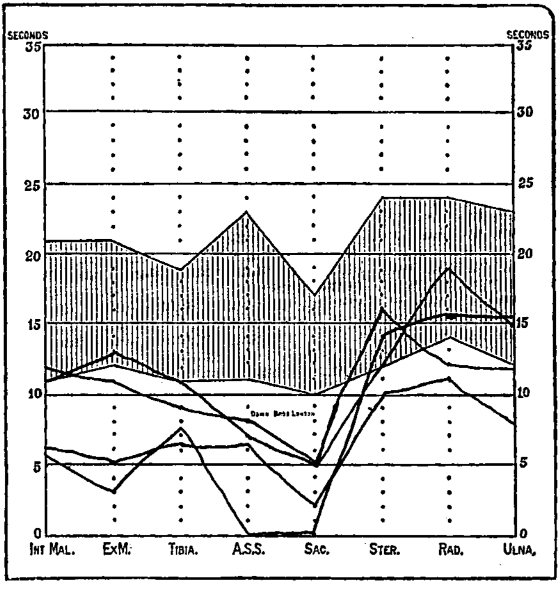

FIG. 2.—Vibration response in 4 cases of tabes.

It is beyond the scope of this article to enter into a discussion of the nature of the vibration sensation and its relation to other sensations. Suffice it to say that under certain pathological conditions of the nervous system there is definite departure from the normal.

The most notable variation of a fixed sort was seen in tabes, as has been mentioned. Eighty cases were studied in various stages, and in large part these cases were kept under prolonged observation watching changes which occur much more markedly in vibration than in any other sensation. In not one of this series was there an exception to the rule that in the lower half of the body there always occurs a reduction in the time of appreciation of vibrations of a fixed amplitude. This reduction in time was singularly constant in its occurrence over the sacrum. It is rare indeed in any case of tabes, however early, to record a time of more than five seconds over this point. In a large proportion of the cases there was no response at all over this portion of the body. In two or three instances the time recorded was as much as six or even seven seconds. Fig. 2 shows the curves of 4 cases of tabes overlaid. The general tendency to dip at the sacrum is well illustrated. In many instances this low response or absence of response occurs when the instrument is applied to the anterior-superior spines of the ilia. It is exceptional for the curve in tabes to fail to fall within the normal range in the upper extremity, and in some instances there is really a high response in this part of the body. This is one of the distinctive differences between tabes and multiple neuritis. In the latter the normal range is seldom encroached on at any point and the "sacral dip" is absent.

This study has led to the conclusion that loss of vibration appreciation is the first sensory loss in tabes. This is illustrated in a man studied in the Addison Ward, Guy's Hospital, whose diagnosis was thoracic aneurysm. The blood in this case was Wassermann negative while the spinal fluid was strongly positive. There were no disturbances of tendon reflexes; the pupils were negative and careful study of skin sensation failed to reveal any areas of analgesia. The curve represented in Fig. 3 shows a low vibration response. It will be noted that the loss is not total but merely a quantitative change which would be readily overlooked were the investigation merely qualitative. This patient was held in the hospital over a long period, and we had the satisfaction before his discharge of seeing the development of areas of analgesia over the tibiæ. It seemed justifiable after a study of a number of such cases to conclude that analgesia followed the alteration of vibration response. In many instances the finding of a low vibration response prompted a careful study of the whole body surface, with the result that certain areas of analgesia were sometimes found. In Fig. 4 the patient, whose reflexes were preserved, showed no appreciation of pain when a pin was plunged into the tip of his nose deep enough to hold it in position. Vague gastric cases in which pain was the predominating factor, studied by the vibration test, proved the usefulness of the procedure. In some clinics gastric crisis as a very early symptom of tabes is frequently noted. Why there should be a difference in this observation in different places is not readily understood. In collecting the normal hundred on which the normal range was established gastric cases were sought after because of the non-neurological character. This opened up a most interesting field, for it was found that in a number of instances these cases showed extraordinary abnormalities in the vibration response. In one case a tentative diagnosis of carcinoma had been made by a very capable house physician. Study of the nervous system showed gastric crisis in early tabes. In another case in the same ward ulcer had been diagnosed and the patient had been on rigid treatment for some time. Vibration study opened the way for a correction of the diagnosis, which was clearly gastric crisis in early tabes. Recently a case was studied in which the vibration response was distinctly that of tabes. Gastric pain was the symptom, and a most careful chemical and fluoroscopic study had been made. The tendon reflexes were preserved and there was no Argyll Robertson pupil, though the pupils were contracted. Analgesia of the skin of the face as well as other scattered areas suggested tabes, which was verified by spinal puncture. In

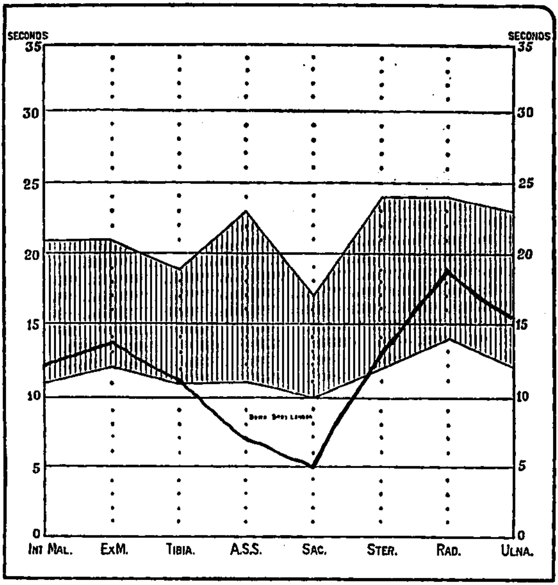

FIG. 3.—Man, aged fifty-five years. Admitted to Guy's hospital (Addison Ward) for aneurysm. The blood was Wassermann negative but the spinal fluid was strongly positive. The vibration curve was that of tabes, and he was kept in the hospital until other signs developed sufficient for a confirmation of this diagnosis. (Guy's Hospital Reports, January 1921).

still another case now under observation the diagnosis of carcinoma seemed well justified, but vibration suggested tabes, which was borne out by the Wassermann test and cell count of the spinal fluid.

In the 80 cases studied there has not occurred a single instance in which there was not a definite time reduction in vibration response, which usually manifested itself in the form of the "sacral dip." In this other points of the lower half of the body frequently shared. It can be safely stated that any case with no reduction in the time of vibration response over the sacrum is not tabes, an observation which can be easily made in one-half a minute and relied upon without further investigation.

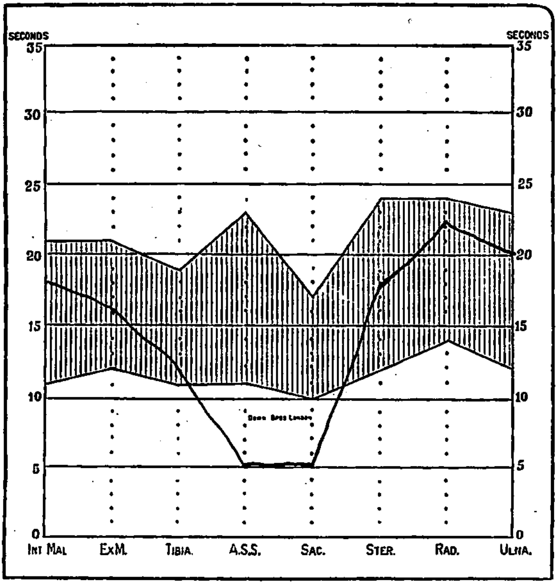

FIG. 4.—Tendon reflexes preserved. Marked analgesia of the skin of the face..

In multiple neuritis there was noted decided reduction in the vibration time. The distinctive "sacral dip or the notch," so marked in tabes, did not occur in any case. There was a general reduction of the time, but a tendency for the sacral point to be relatively high and in many cases higher than the other points. In addition to this there was usually absent that tendency so marked in tabes for the time response of the upper extremity to be normal, making a curve which in that part of the body falls well within the normal range. In diabetes it was interesting to record the improvement in sensation indicated by the vibration curve in those cases receiving proper dietetic treatment. In a case of multiple neuritis occurring in a woman who was a victim of pellagra, seen in the service of Dr. Edwin Bramwell, in the Royal Infirmary, Edinburgh, there was this definite reduction in vibration time with the high point over the sacrum. It was notable in this case that pain and tactile sensations were not disturbed and temperature sense only slightly. The vibration time is recorded in Fig. 5.

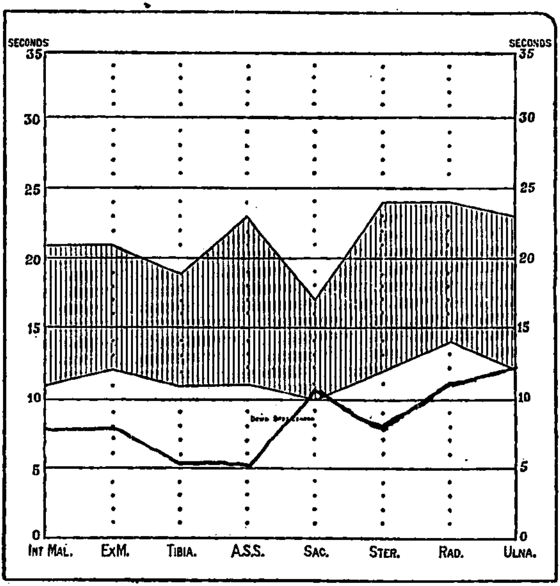

FIG. 5.—Multiple neuritis in pellagra.

Three cases of Friedreich's ataxia were studied in Guy's Hospital and showed a loss in the vibration time quite like the changes noted in early tabes. The loss of vibratory appreciation was not complete, and would have been overlooked if a qualitative test alone had been made. As in tabes there is a "sacral notch" in the curve of these cases.

Subacute combined degeneration of the spinal cord in association with pernicious anemia was studied in 5 cases. In all cases there was a definite loss of the vibration response which, until late in the process, was confined to the lower half of the body, with little abnormality in the upper half. In 1 of these cases the·loss was complete in the feet; marked over the tibiæ, but not entirely lost; less over the anterior-superior spines and still less over the sacrum, with a gradual ascent in the upper portion of the body. This is seen in Fig. 6, which is made of 2 such cases.

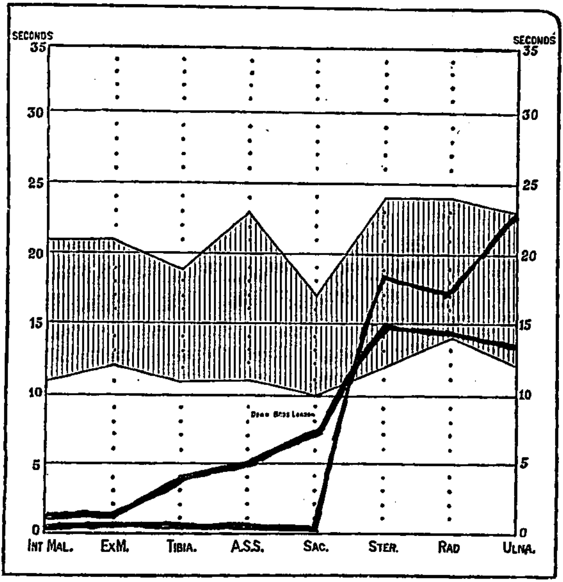

FIG. 6.—Two cases of subacute combined degeneration of the cord in pernicious anemia.

In all of these cases the "sacral notch" of tabes was not pronounced. The curve can be readily distinguished from that of multiple neuritis.

One case studied caused much confusion because the response over the sacrum was entirely absent while the blood and spinal fluid were negative to the Wassermann reaction. Incontinence of bowel and bladder were present. Study of skin sensation about the anus and down the lower limbs gave the characteristic findings of a lesion of the cauda equina.

One of the most fertile fields for the study of the vibration sensation is syphilitic meningomyelitis. In this condition the vibration response was found to be reduced in the lower half of the body, but there was more evidence of asymmetry than is usually noted in such cord lesions as tabes. The great helpfulness of the test seems to be in gauging improvement. It seems probable that an improvement in the spinal fluid will run more or less parallel with an improvement in sensation, and this may be measured in a quantitative way by using the vibration sensation. A beginning only has been made in this work which requires much time and very exact laboratory work by an expert serologist.

In conclusion, I would express my thanks to Dr. A. F. Hurst, of Guy's Hospital, under whom the work was done for aid of every sort; to Dr. Gordon Holmes, for suggestions and clinical opportunities at the National Hospital, Queen Square, at Charing Cross Hospital and at Moorfields; to Dr. Edwin Bramwell, for material and much aid at the Royal Infirmary, Edinburgh; to Sir James Mackenzie, for an opportunity to do further work at the Clinical Institute of St. Andrews, Scotland.

PERIPHERAL AND RADICULAR TYPES OF EPIDEMIC ENCEPHALITIS.[1]

By Foster Kennedy, M.D.,
NEW YORK.

It is only for the purpose of presentation of different clinical aspects of epidemic encephalitis by different observers that we have in this conference divided with some arbitrariness the disease into different clinical groups. A clinical discussion under these circumstances therefore must begin by a disclaimer that the type assigned to each author is ever a disease of its own genus, and by an assertion that it merely represents a variety in which the virus has fallen with some greater incidence on one part of the body than on another. Of the circumstances which go to permit this variety of form we know little: naturally, disease pictures will vary with the structure affected and variety in such pictures following nervous lesions is furthered because from lesions of the nervous system we may have either obliteration of normal function or release of functions normally controlled by centers higher in the neural hierarchy.

It is probable that variety of clinical form in epidemic encephalitis is also often produced by variety of virus or by a constant virus

---

[1] Read before the Association for Research in Nervous and Mental Diseases, December 29, 1920.